Graphical Interface for Embedded Processors Using MATLAB Based GUI

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***Abstract*— In industries often stand-alone embedded system is preferred rather than big and bulky desktop computer. In order to make the system more interactive graphical interface is used. Here we have developed graphical interface using MATLAB GUI for PIC microcontroller and thus for embedded processor.[1] MATLAB is used more preferably by engineers for technical computing purpose and for creating GUI for processor based systems.**

The main objective is to make GUI independent of the platform of operating system and computer. This is achieved by converting or compiling MATLAB file into the executable file called .exe file.

Keywords— MATLAB, PIC processor, RS232 protocol, MPLAB IDE, PIC Kit 2 downloader etc.

I. INTRODUCTION

Electrical loads are often needed to be controlled and monitored in the industries. This is done with the help of embedded processors such as PIC microcontrollers. PC based monitoring and control has added advantage to this system. For this MATLAB based GUI is used to control and monitor parameters of system.

Chapter I give introduction of the system design. Chapter II explains the Block diagram. Chapter III gives information on software requirements of the system such as MPLAB and MATLAB IDE. Chapter IV explains steps for compilation of .m file into .exe file whereas Chapter V explains downloader for PIC microcontroller of hex file.

II. SYSTEM DEVELOPMENT

A. Block Diagram of overall system

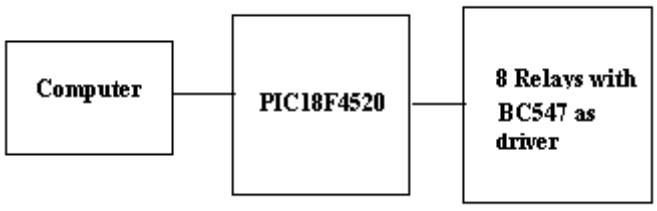

Fig 1: Block diagram of the system design

B. Features of PIC Microcontroller

Following are some of the important features of PIC18F4520 microcontroller.[1]

1. 40-pin Low Power CMOS Microcontroller
2. Flash Program Memory: 32 kbytes
3. EEPROM Data Memory: 256 bytes
4. SRAM Data Memory: 1536 bytes
5. I/O Pins: 36
6. Timers: One 8-bit / Three 16-Bit
7. A/D Converter: 10-bit Thirteen Channels
8. PWM: 10-bit Two Modules
9. Enhanced USART: Addressable with RS-485, RS-232 and LIN Support
10. MSSP: SPI and I²C Master and Slave Support
11. External Oscillator: up to 40MHz
12. Internal Oscillator: 8MHz

Fig 2: PIC18F4520 Microcontroller in PDIP Package

C. RS232 Standard for serial communication

To transmit the data either serially or to receive the data serially the RS 232 standard is widely used in the industry. In computer, at the back side there is serial port of 9 pin connector called DB-9 connector which is used to connect the devices serially.[2] In RS 232 data is transferred serially one bit at a time, in contrast with the parallel communication where all 8 bits are transmitted at once.

D. Relay Interfacing with PIC Microcontroller

Current sourcing capacity of PIC microcontroller is only 25mA. External devices such as high-power LEDs, motors, speakers, light bulbs, buzzers, solenoids, and relays though they require same voltage of 5V, current requirement may be different like few hundreds of ohm. In order to increase the current level supplied to the devices a transistor may be used. Transistor acts like high speed switch which is controlled by the microcontroller output pin as shown in Fig 3.

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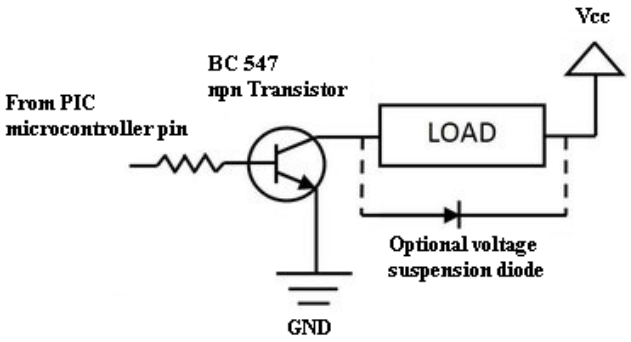

Fig 3: Basic driver circuit using a BJT transistor

Here transistor is used for increasing the current gain of the circuit. Base resistor is used is of the order of 1KOhm. On inductive loads (i.e., motors, relays, solenoids), a diode is often connected backwards across the load to suppress the voltage spikes (back EMF) generated when turning devices off. This is because V=L*di/dt, so a negative voltage spike is produced when turning the device off.

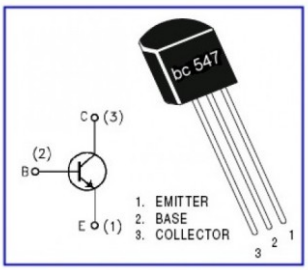

Fig 4: Pin diagram of NPN transistor BC547

E. Serial Communication in PIC Microcontroller

Only two registers are used for serial communication in PIC18F4520 microcontroller. These registers are
TXSTA - Transmit Status and Control Register
RCSTA - Receive Status and Control Register

To enable serial communication between computer and PIC microcontroller we must set baud rate between them. For typical baud rate of 9600 kbps we must save SPBRG register value to 31 (in decimal). SPBRG register is serial port baud rate register which is 8 bit register.
Formula for calculating baud rate is as follows;
For High Speed:
SPBRG = (Fosc / (16 x Baud rate)) - 1, BRGH = 1
For Low speed:
SPBRG = (Fosc / (64 x Baud rate)) - 1, BRGH = 0

By setting the values in the SPBRG register equal to 31, we configure PIC microcontroller for serial communication at the rate of 9600 kbps. By putting proper values in TXSTA=0x90 and RCSTA=0x20 serial port is enabled for communication.

III. SOFTWARE REQUIREMENT OF DESIGN

Any embedded application requires support from the software and hardware also. Controlling the hardware without the software is not possible. Following types of software are required for system;

A. MPLAB IDE

MPLAB IDE is software development environment for development of PIC microcontrollers. MPLAB IDE is supported by various operating systems including Windows, Mac OS and Linux. It is called an Integrated Development Environment (IDE), because it provides a single integrated "environment" to develop code for embedded microcontrollers. MPLAB® X IDE is based on the open source NetBeans IDE from Oracle. MPLAB IDE is freely available on the microchips website http://www.microchip.com/.[10]

B. PIC18F4520 Firmware

The firmware of PIC microcontroller is compiled and downloaded by using MPLAB IDE. It receives a serial character from computers serial port and operates accordingly. [5]
A sample code is given here;

```
#include <P18F4520.h>
void main (void)
{
unsigned char x;
TRISD = 0; // set PORTD as o/p
RCSTA=0x90; // SPEN=1, CRES=1
SPBRG=31; // Baud rate=9600
while(1)
{
while(PIR1bits.RCIF==0); // wait while char is received
x=RCREG; // write received char to PORTD
if(x=='a')
      PORTDbits.RD7=0;
…
…
}
```

C. MATLAB IDE

MATLAB language is used by engineers and scientists worldwide. MATLAB IDE is language of technical computing. GUI for the system is designed by using the MATLAB language. MATLAB stands for Matrix Laboratory. It is the language of technical computing. GUIs (also known as graphical user interfaces or UIs) provide point-and-click control of software applications, eliminating the need to learn a language or type commands in order to run the application. MATLAB apps are self-contained MATLAB programs with GUI front ends that automate a task or calculation. The GUI typically contains controls such as menus, toolbars, buttons, and sliders [4].

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D. Capabilities of MATLAB software

MATLAB is capable of doing various kinds of operations. Some of them are listed below;

1. Numeric Computation- Use mathematical functions to solve science and engineering problems
2. Data Analysis and Visualization - Explore, visualize, and model your data
3. Programming and Algorithm Development - Create and optimize algorithms using the high-level language and development tools
4. Application Development and Deployment-Develop and share applications as code, executables, or software components

E. Code of MATLAB for GUI

We have to program for every push buttons present in the GUI accordingly.[6] GUIDE can be invoked in MATLAB by simply typing >>guide in the command window. MATLAB GUI dialog box will appear, follow the steps and create the GUI as show in below Fig 5.

Sample code for push button is as follows;

```
function pushbutton_Callback(hObject, eventdata,
handles)
% hObject    handle to pushbutton69 (see GCBO)
% eventdata  reserved - to be defined in a11 future
version of MATLAB
% handles    structure with handles and user data (see
GUIDATA)
clear all;
s=serial('COM1');
set(s,'BaudRate',9600);
fopen(s);
fprintf(s,'%s','d');
fclose(s)
delete(s)
clear s
imshow('C:\MATLAB
GUI\images\gray.jpg','parent',handles.a11);
```

In this code we have first of all, created serial object via COM1 port which is default in all computer (i.e. serial port). After that select the baud rate to 9600 kbps and open serial port for communication. To indicate whether load is ON or OFF LEDs are indicated on GUI via *imshow()* command in MATLAB.

F. MATLAB GUI

GUI for the system is designed by using static text, axes, push buttons and button panel. It makes system more users friendly. MATLAB file is created for the corresponding GUI and run in the MATLAB software. Prior to run the GUI we need to save MATLAB GUI folder in the C drive at location C:\MATLAB GUI\images. If this is not saved it will produce an error suggesting undefined location for images. [3]

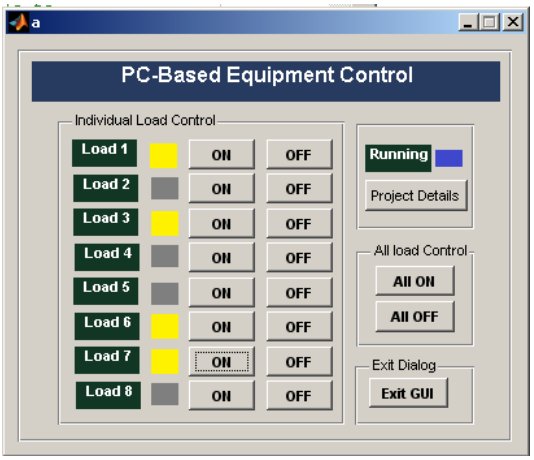

Fig 5: MATLAB GUI front panel

IV. COMPILATION OF MATLAB FILE

Since all the computers do not have MATLAB installed, to make .m file independent we have to convert it to executable form. This is done as follows-

In command window type-

>> mcc –mv –o myExecR2013a myStandalone.m myApp.m

% . . .

- -mv produces a standalone and shows actions taken
- -o myExecR2013a specifies the executable name. Though not required, "R2013a" indicates MATLAB release used for compilation.
- myApp.m is an example of your main program. The standalone procedure supports most toolboxes.

V. PIC KIT 2 DOWNLOADER

PIC Kit 2 is used for programming the PIC flash microcontrollers. It is low cost programming tool. It supports PIC12, PIC16, PIC18 and PIC24 families from PIC microcontroller. It also enables in-circuit debugging of PIC microcontrollers.

All MPLAB software versions are free to download. The main reason for selecting PIC microcontroller is compilers are freely available and open source i.e. compilation and creation of hex file is relatively easy as compared with other microcontrollers.

Microchip Company itself has developed PIC kit 2 for downloading of hex file into program memory of PIC microcontroller as shown in Fig 6.

Fig 6: PIC kit 2 for downloading hex file

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CONCLUSION

Thus electrical equipment control is possible with the help of PC and PIC microcontroller. GUI in this gives more advantage to make system more users friendly which is the one of the characteristics of embedded system. By making m file to executable file we can make system independent from the computer's hardware.

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